The U.S. Navy's Task Force Climate Change

RADM Dave Titley
Oceanographer of the Navy
Director, Task Force Climate Change
November 2011

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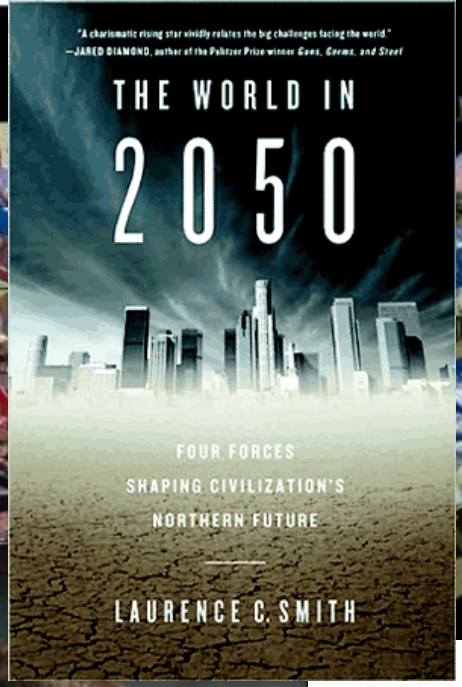
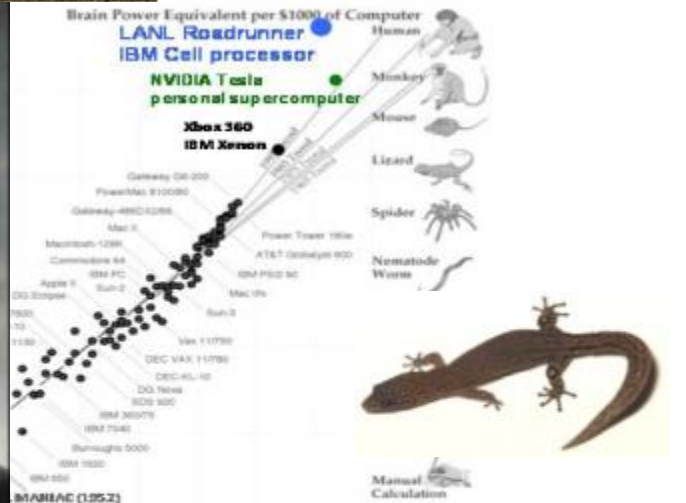
World Population (est.) 10,000 BC - 2,000 AD
billions of people
7
6
5
4
3
2
1

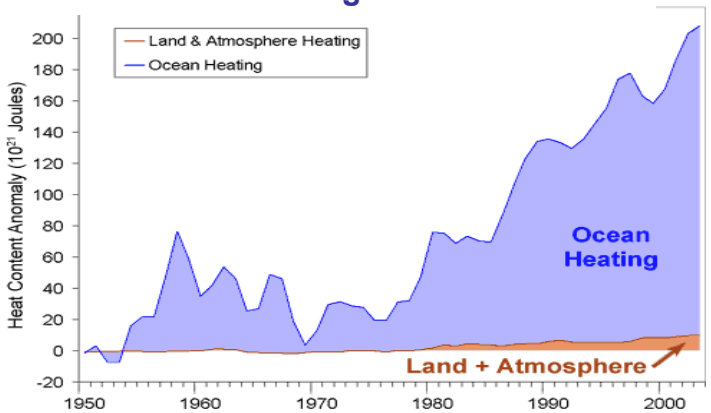

"A charismatic rising star vividly relates the big challenges facing the world."
—JARED DIAMOND, author of the Pulitzer Prize winner Guns, Germs, and Steel
THE WORLD IN
2050
FOUR FORCES
SHAPING CIVILIZATION'S
NORTHERN FUTURE
LAURENCE C. SMITH


OPEC


Brain Power Equivalent per $1000 of Computer
LANL Roadrunner
IBM Cell processor
NVIDIA Tesla
personal supercomputer
Xbox 360
IBM Xenon
Human
Monkey
Mouse
Lizard
Spider
Nematode Worm
Manual Calculation
1960
1980
2000
2020
Year
e now for full-scale modeling of the brain.
} will allow large-scale modeling of cortex.
NNSA

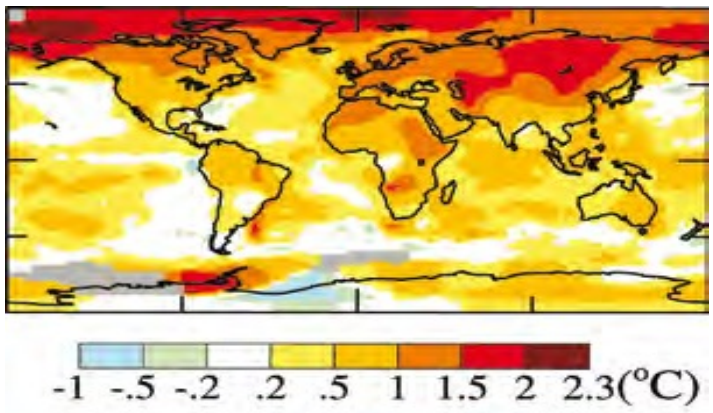
Climate Change

The Ocean is Storing Most of the Heat



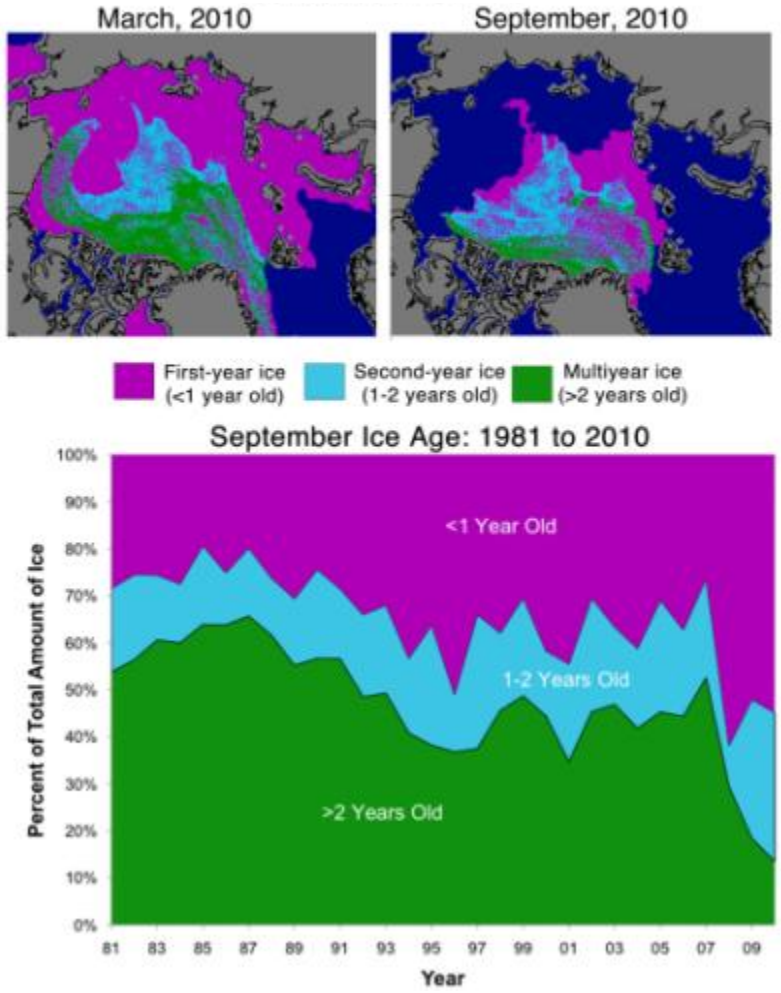
Total Earth Heat Content from 1950 (Murphy 2009). Ocean data taken from Domingues et al 2008

Arctic Warming is 2 x the Rest of the World

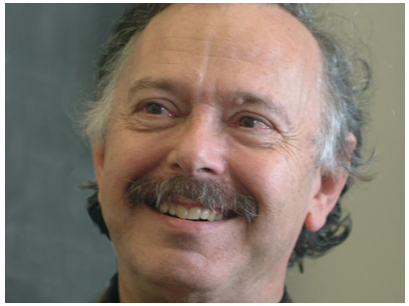


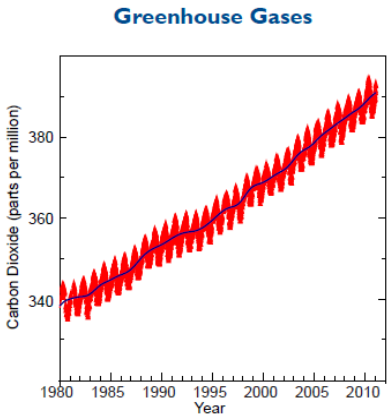
Mean surface temperature 2001-2007 relative to baseline period 1951-1980, from:The Copenhagen Diagnosis, 2009

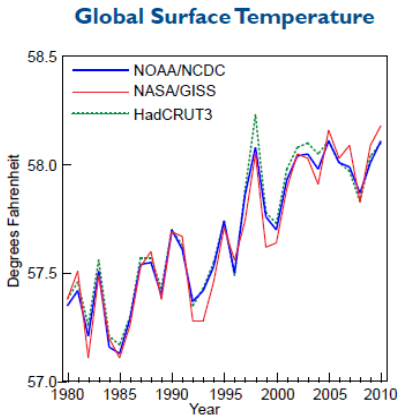
Arctic Sea Ice Continues to Melt & Thin

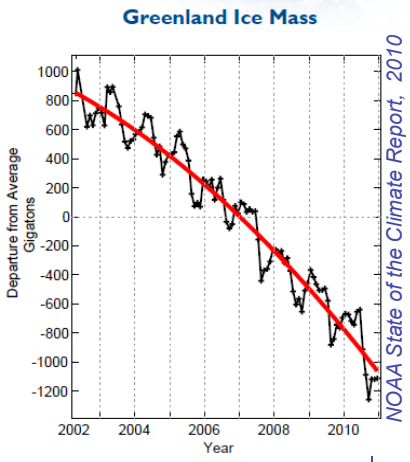


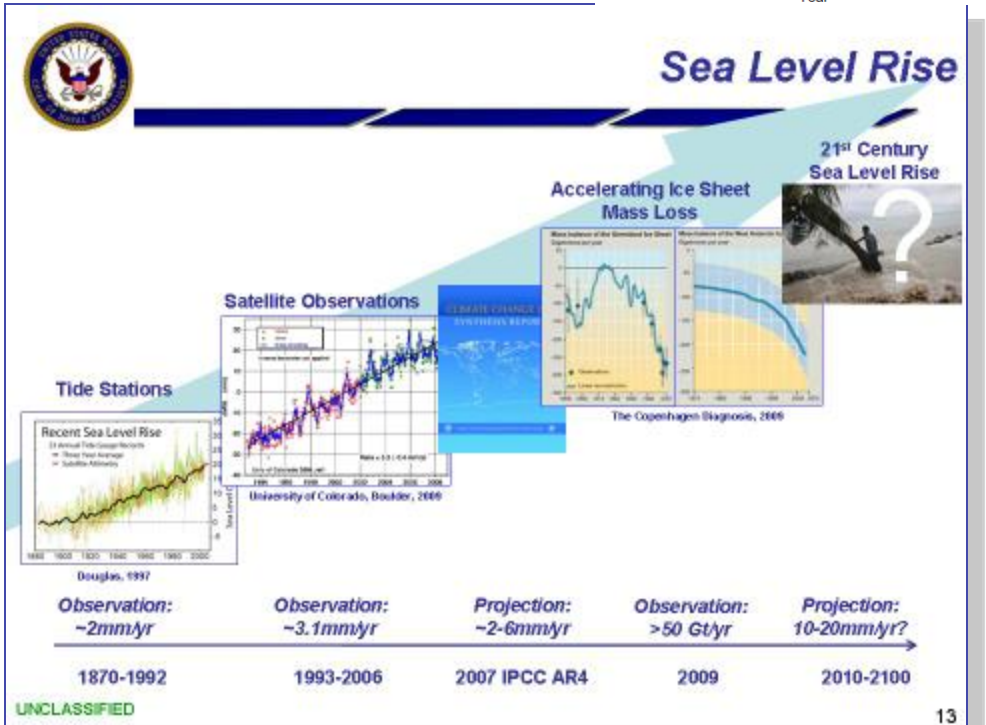
Global Climate Change











So What Does this Mean?

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Climate Change Causes

$$\gamma(1+\beta\mu)\frac{\partial I_\nu}{\partial t}+\gamma(\mu+\beta)\frac{\partial I_\nu}{\partial r}$$
$$+\frac{\partial}{\partial\mu}\left\{\gamma(1-\mu^2)\left[\frac{1+\beta\mu}{r}-\gamma^2(\mu+\beta)\frac{\partial\beta}{\partial r}\right.\right.$$
$$\left.\left.-\gamma^2(1+\beta\mu)\frac{\partial\beta}{\partial t}\right]I_\nu\right\}-\frac{\partial}{\partial\nu}\left\{\gamma\nu\left[\frac{\beta(1-\mu^2)}{r}\right.\right.$$
$$\left.\left.+\gamma^2\mu(\mu+\beta)\frac{\partial\beta}{\partial r}+\gamma^2\mu(1+\beta\mu)\frac{\partial\beta}{\partial t}\right]I_\nu\right\}$$
$$+\gamma\left\{\frac{2\mu+\beta(3-\mu^2)}{r}+\gamma^2(1+\mu^2+2\beta\mu)\frac{\partial\beta}{\partial r}\right.$$
$$\left.+\gamma^2[2\mu+\beta(1+\mu^2)]\frac{\partial\beta}{\partial t}\right\}I_\nu=\eta_\nu-\chi_\nu I_\nu\,. \qquad (1)$$

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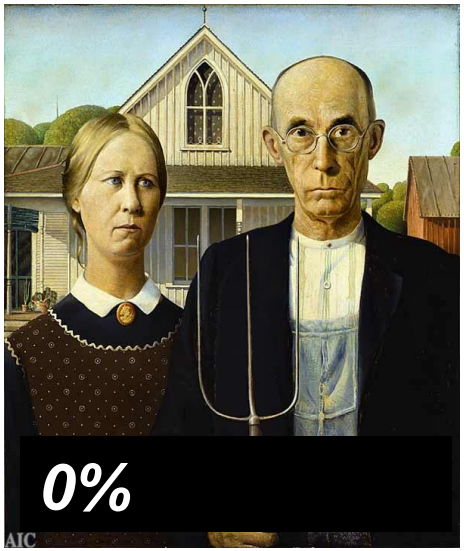
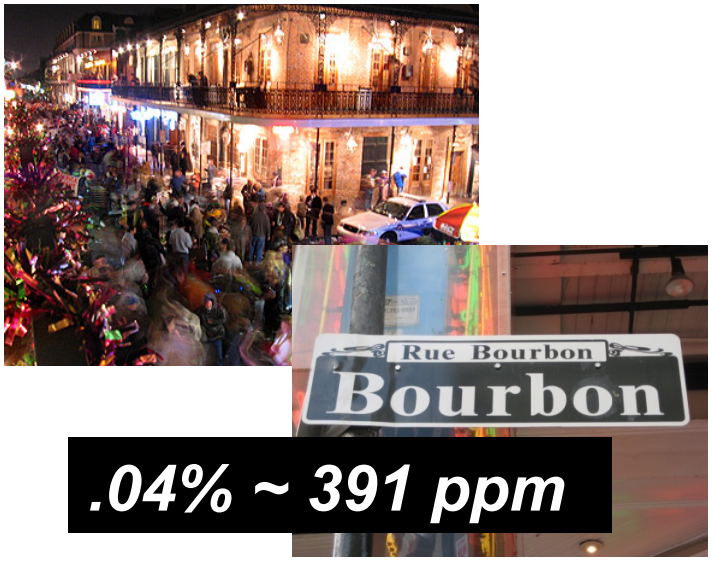
Sometimes I hear…

"Carbon dioxide is just a trace gas"



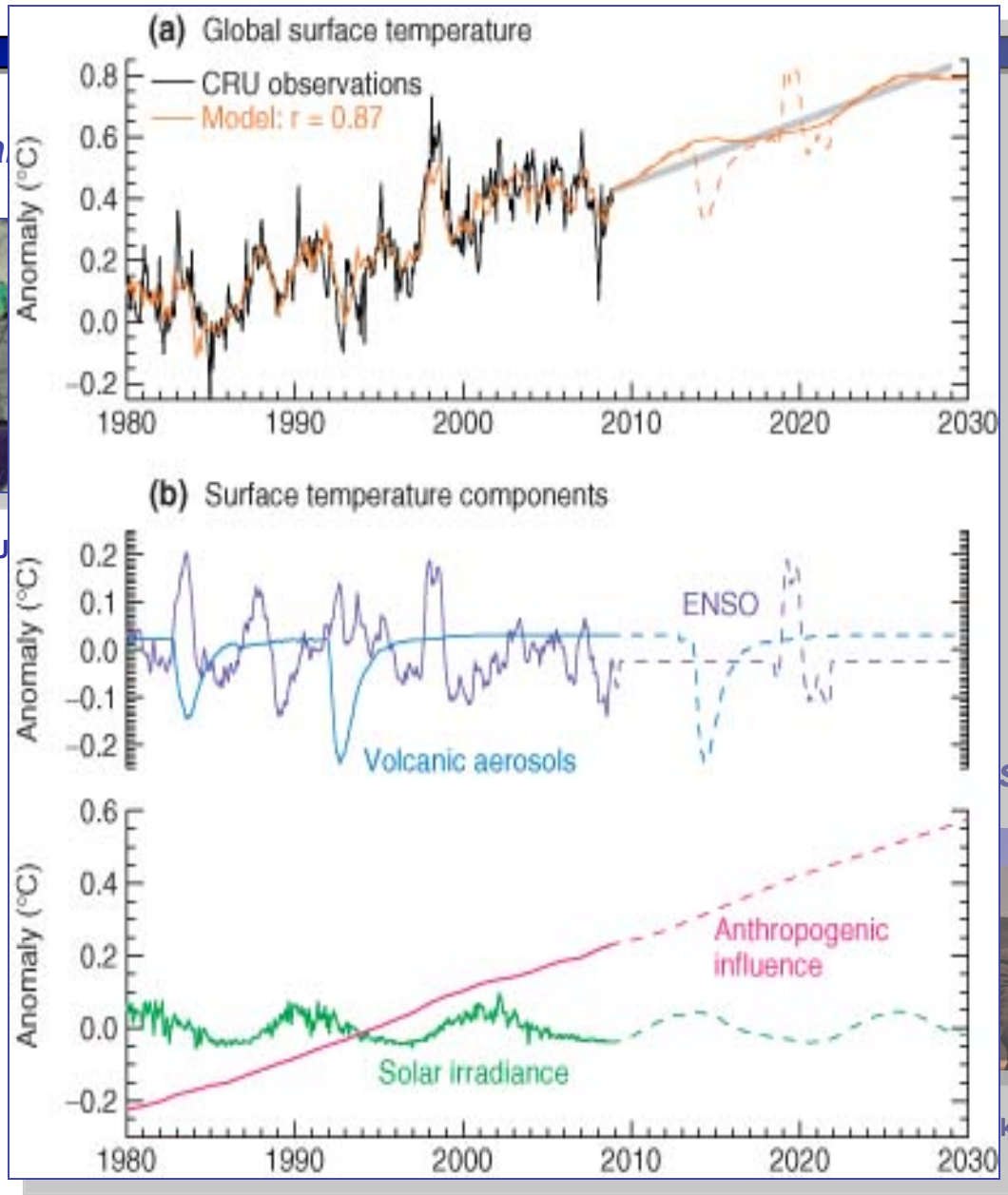


Drinks	100	120	140	160	180	200	220	240	
0	.00	.00	.00	.00	.00	.00	.00	.00	Only Safe Driving Limit
1	.04	.03	.03	.02	.02	.02	.02	.02	
2	.08	.06	.05	.05	.04	.04	.03	.03	Driving Skills Impared
3	.11	.09	.08	.07	.06	.06	.05	.05	
4	.15	.12	.11	.09	.08	.08	.07	.06	
5	.19	.16	.13	.12	.11	.09	.09	.08	
6	.23	.19	.16	.14	.13	.11	.10	.09	
7	.26	.22	.19	.16	.15	.13	.12	.11	Legally Intoxicated
8	.30	.25	.21	.19	.17	.15	.14	.13	
9	.34	.28	.24	.21	.19	.17	.15	.14	
10	.38	.31	.27	.23	.21	.19	.17	.16	Possible Death

Climate Change Causes (cont'd)

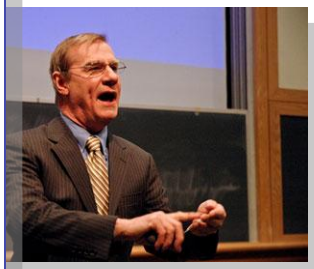
"It's part of a la

John Coleman, KU



Judith Lean, "Cycles and Trends in Solar Irradiance and Climate," 2009

s little to do with it."



k Michaels, CATO Institue

Security Implications

Climate Change

- Weather
- Ocean
- Land
- Space

Impacts

- Food
- Water
- Shelter
- Energy
- Health

Factors

- Exposure
- Sensitivity
- Adaptability

Response

- Defense
- Diplomacy
- Development

Implies a National "whole of government" approach

In The Beginning…

September 2007

Arctic Ice Decline

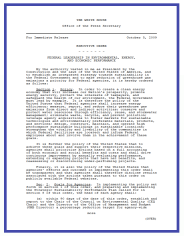
October 2007

CS-21

Maritime Strategy

January 2009

NSPD-66



National Arctic Policy

April 2009

CNO

CNO Direction

May 2009

NAVY
Task Force
Climate Change

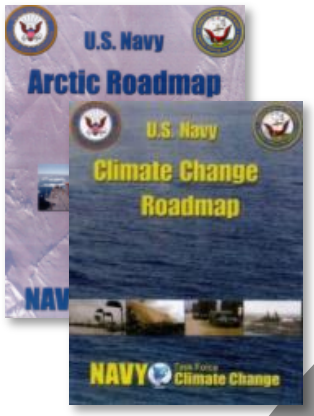
TFCC Established

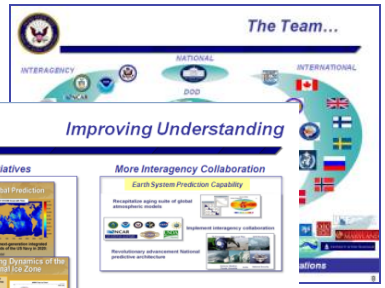
Science-based approach, leverage partnerships, assess risk

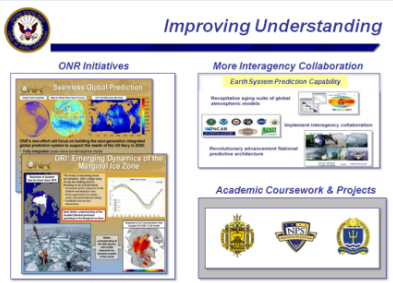
The Team…

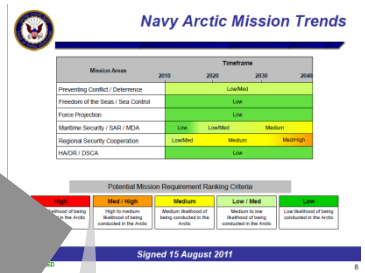
Engaged nearly 600 individuals from over 175 organizations

U.S. Navy Task Force Climate Change









Assessment

Inform Policy & Resource Decisions

Science & Network

Roadmaps

Monitor Conditions

Update Roadmaps

Science-based approach, cooperative partnerships, risk assessments

Navy Engagement

Defense

Coordination & support to multiple OSD offices

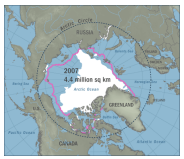
USEUCOM / SACEUR Flag-level meetings

USPACOM Environmental Security Conference

USNORTHCOM Flag-level Meetings

National

National Ocean Policy Implementation



National Security Staff's Arctic Interagency Policy Committee

US Global Change Research Program

Congressional

US-UK Statement to US CODEL

House and Senate committee testimonies

Multiple briefings to HAC-D, SAC-D, HASC, and SASC staffs

International

Operation NANOOK/NATSIQ

USS Taylor Port Visit to Murmansk

Conferences & symposia

US – Foreign Navy Staff Talks

Media

Radio interviews

On-line publications

New media

Traditional printed outlets

Demonstrating leadership

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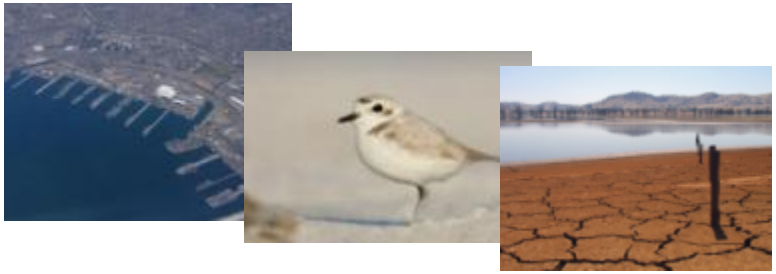
Navy Concerns

Operations & Plans

- Increasing Arctic maritime activity
- Adaptation partnerships opportunities
- Potential increase in Humanitarian Assistance/Disaster Response



Installations & Environment

- Impact of sea level rise
- Water resources
- Natural & cultural resources

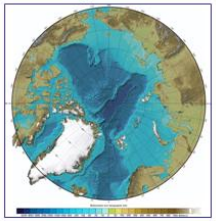
Wild-cards

- Ocean acidification
- Abrupt climate change
- Geoengineering

It's all about Readiness

Arctic Considerations

Poorly Charted



Limited Infrastructure

Harsh Operating Environment

Security Concerns

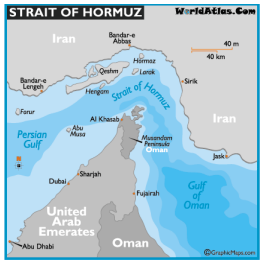
Transportation Access

U.S. Native Perspectives

AEWC

One Scenario

+



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Navy Arctic Strategic Objectives

Signed by CNO on 21 May 2010

I. Contribute to safety, stability, & security in the region

IV. Strengthen existing & foster new cooperative relationships in the region

II. Safeguard U.S. maritime interests in the region

V. Ensure Navy forces are capable and ready

III. Protect the American people, our critical infrastructure, & key resources

Towards the desired end state: a safe, stable, and secure Arctic

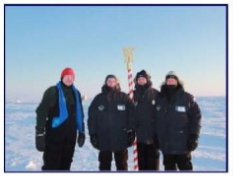
Navy Activity On and Under the Ice

Technology Demonstrations – ICEX-11

Aerial resupply

SSN 778 surfaced

Ice-mining



VIP visit

Interagency Research Efforts – Operation Ice Bridge 2011

Greenland Ice Sheet

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Navy Arctic Mission Trends

Mission Areas	Timeframe			
	2010	2020	2030	2040
Preventing Conflict / Deterrence	Low/Med			
Freedom of the Seas / Sea Control	Low			
Force Projection	Low			
Maritime Security / SAR / MDA	Low	Low/Med	Medium	
Regional Security Cooperation	Low/Med	Medium	Med/High	
HA/DR / DSCA	Low			

Potential Mission Requirement Ranking Criteria

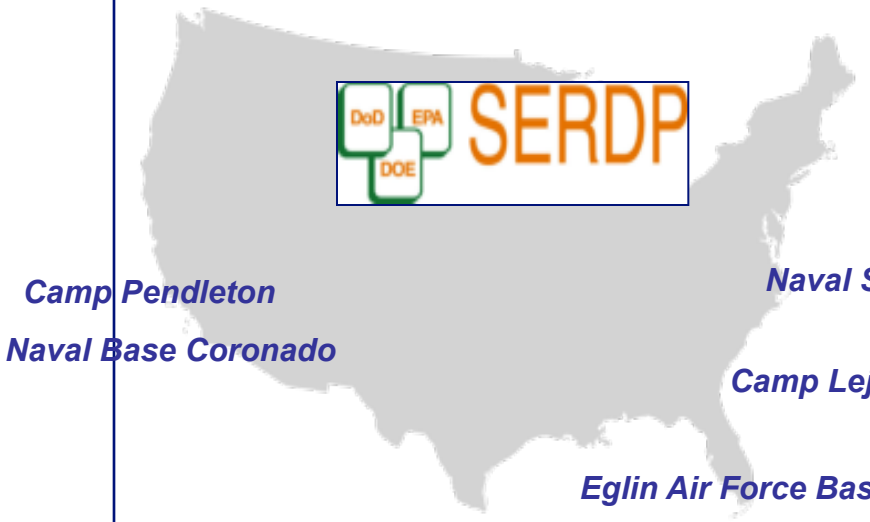
High	Med / High	Medium	Low / Med	Low
High likelihood of being conducted in the Arctic	High to medium likelihood of being conducted in the Arctic	Medium likelihood of being conducted in the Arctic	Medium to low likelihood of being conducted in the Arctic	Low likelihood of being conducted in the Arctic

Signed 15 August 2011

Navy Installation Vulnerability

Physical Impacts

- Inundation
- Wetlands
- Erosion patterns & rates
- Surface/ground water supplies
- Water tables
- Tidal flows & currents
- Storm & flood damage



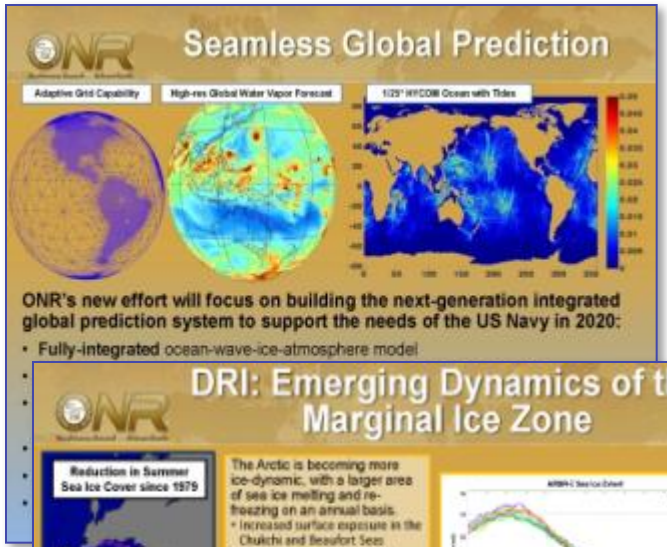
Navy Study

- Identify most vulnerable installations
- Local and regional infrastructure
- Prioritize spending
- Maintain mission readiness

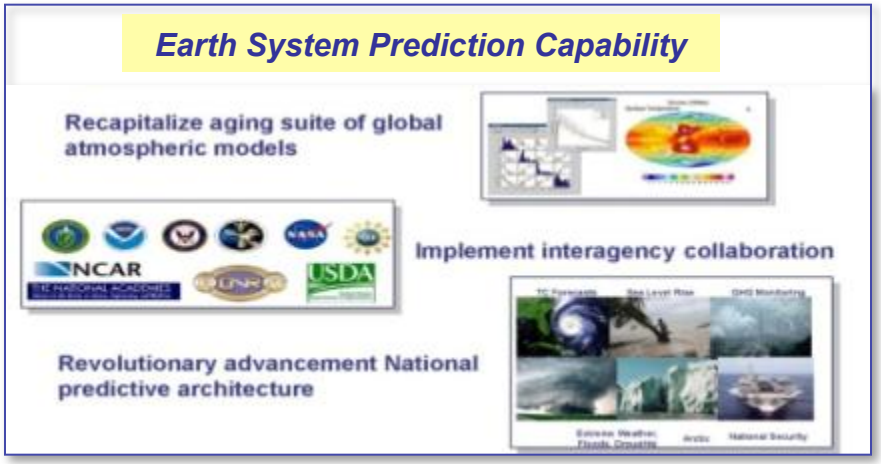
Enabled & informed by sound science

Improving Understanding

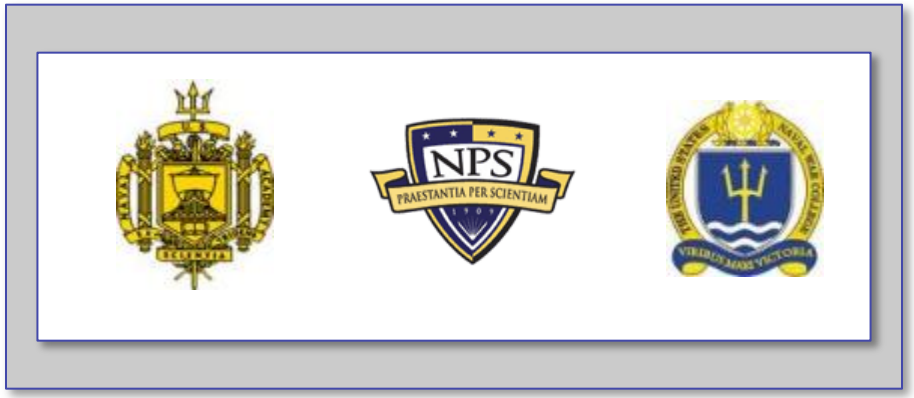
ONR Initiatives



More Interagency Collaboration



Academic Coursework & Projects



Navy Accomplishments: Feb – Nov 2011

Education

Studies & Assessments

Outreach & Engagement

Naval Arctic Mission Analysis & Capabilities Based Assessment

Naval War College
- Fleet Ops Game
- Arctic Symposium

USNA Interns

Support for UNCLOS Accession

NASA CASI Workshop

Naval Studies Board study

Congressional Testimonies

Leadership visits & staff talks

Naval Installation Sea Level Rise Vulnerability Assessment

Sustaining Military Readiness Conference

Arctic Security Roundtable

Science & Research

Operations & Training

Policy, Strategy, & Plans

Arctic Security in an Age of Climate Change

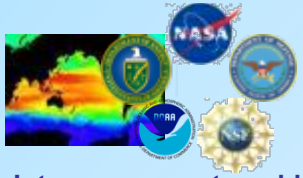
Russia Maritime Working Group Meeting

OSD-Policy Arctic Report to Congress

USN-USCG Staff Talks

ICEX 2011

Pacer Goose



Interagency partnership For air-ocean-ice numerical prediction

NASA IceBridge

Science Ice Exercise Plan

Improve understanding

Ensure readiness (resilience)

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Naval Studies Board Recommendations

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine
NAVAL STUDIES BOARD

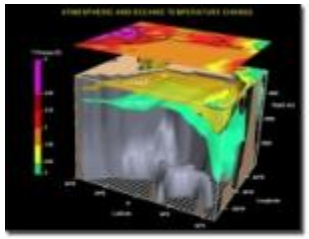
Support ratification of UNCLOS

Address naval coastal installation vulnerabilities

Prepare for increase in HA/DR, Arctic missions

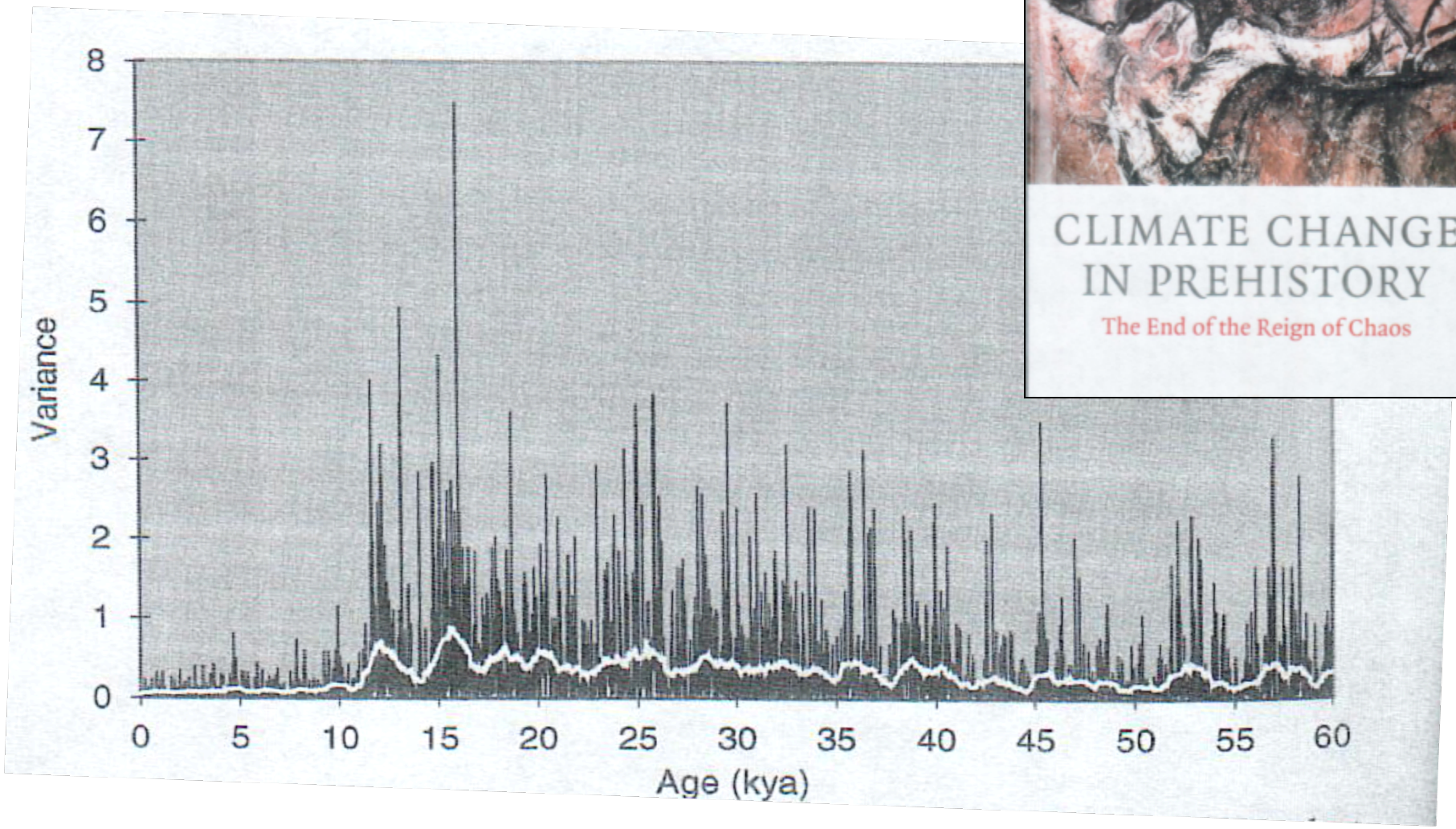
Address emerging technical requirements (e.g. polar ops)

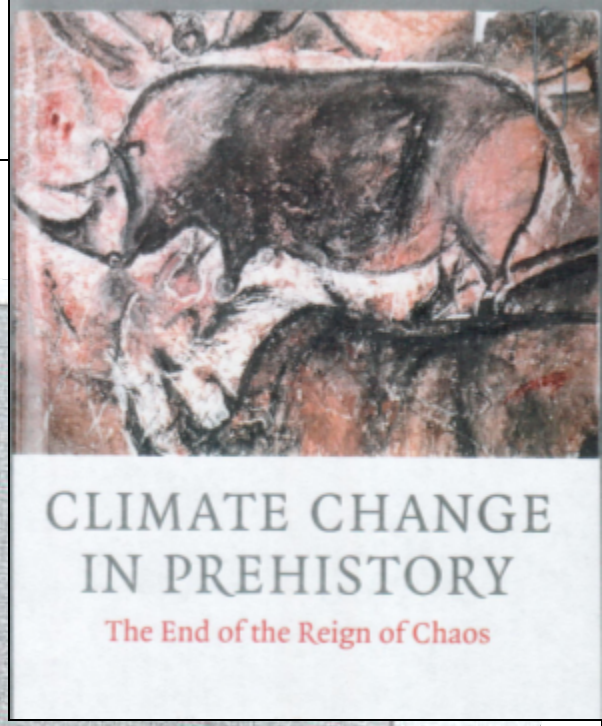
Address partnership demands



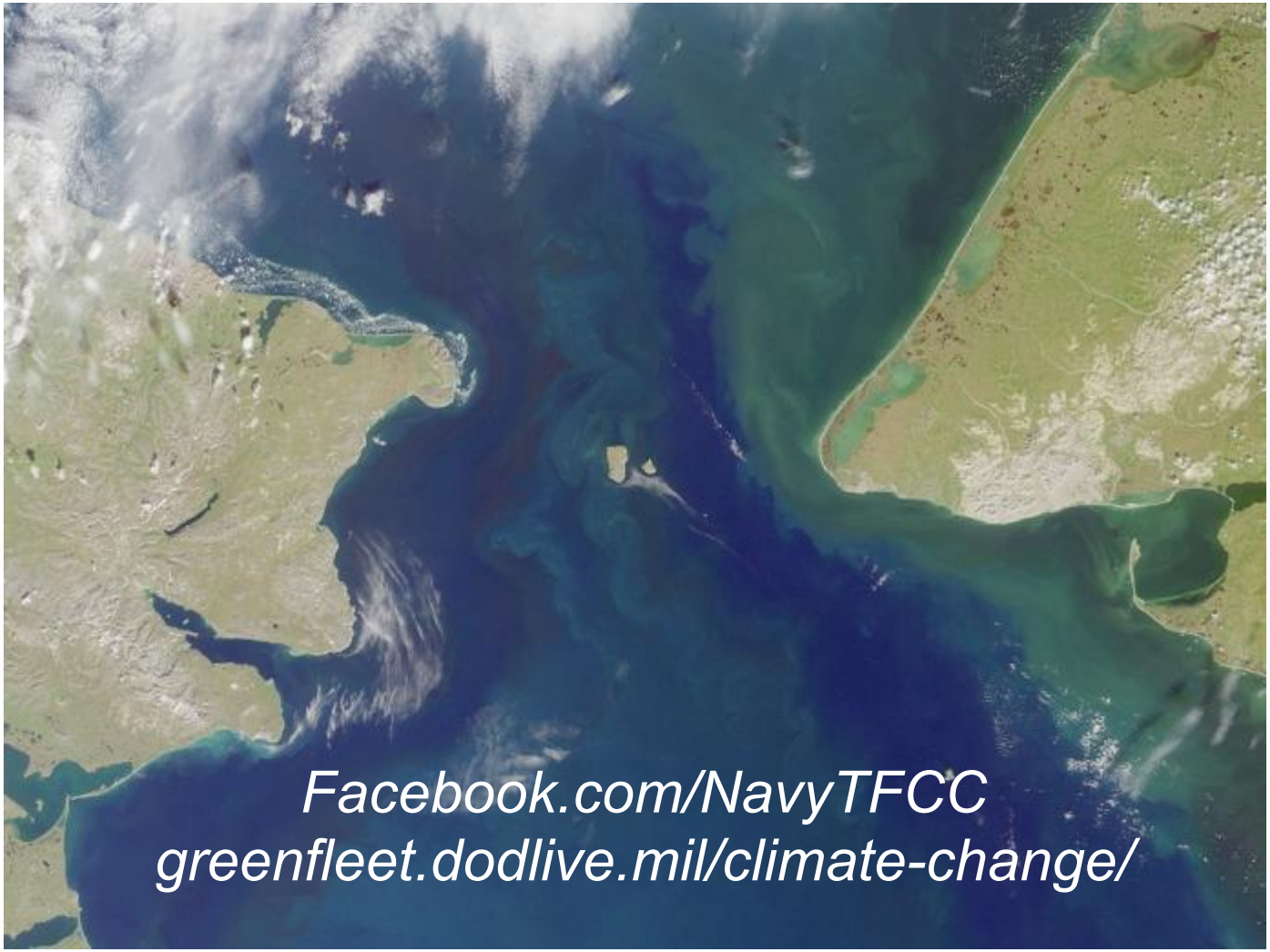
Support research & development

Navy action is already underway


Variance
0
1
2
3
4
5
6
7
8
0
5
10
15
20
25
30
35
40
45
50
55
60
Age (kya)


CLIMATE CHANGE
IN PREHISTORY
The End of the Reign of Chaos

Discussion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greenfleet.dodlive.mil/climate-change/